Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

NOVEMBER, 1916.

THE SCIENTIFIC SPIRIT.

At a time when this country has been forced to recognise the value of science, it will be useful for those who do not understand the scientific point of view to learn something about it.

We would therefore recommend those whose education has been but classical or commercial to read Professor R. A. Gregory's book, to which he has given the title, "Discovery, or the Spirit and Service of Science." *

They will learn how the scientific worker, as a rule, does not carry out his investigations for his own personal profit, although definite researches may be instituted with a special object in view. The opinions and sayings and discoveries of many of the leaders of science, which Professor Gregory has collected together, should be a revelation to those who have enjoyed the benefits of Watt, Davey, and Faraday, but who have not troubled to think of the attitude of mind which led to their inventions. As Professor Gregory says: "The practical man judges scientific research from the point of view of its direct service to humanity, or that of money-making capacity; and he considers that people who devote their lives to studies having neither of these profitable objects in mind are wasting their time and abusing their intellectual faculties.

It comes as a surprise to most men to be told that in scientific circles usefulness is never adopted as the standard of value; and that, even if not a single practical result is reached by an investigation, the work is worth doing if it enlarges knowledge or increases our outlook upon the universe. This proposition, of course, leaves the practical man cold; yet it is all that science desires to offer in justification of its activities. While the discovery of truth remains its single aim, science is free to pursue inquiries in whatever direction it pleases; but when it permits itself to be dominated by the spirit of productive application, it becomes merely the galley-slave of short-sighted commerce."

The chapter entitled "Belief and Evidence" again emphasises that the object of science is to reach the truth, and that its usefulness lies in showing what facts really are. For instance, Professor Gregory exposes the idea that the British climate has undergone any considerable changes in modern times, or, again, that the moon, stars, and planets have any influence on the weather; that conditions of trees in spring have anything to do with the future, or that a great number of berries indicates that the coming winter will be severe.

Recently, at the suggestion of Professor Gregory, the Council of the British Association appointed a committee to consider the question of increasing the number of popular science lectures given in this country, and we cannot but think that if they can be made to bring home to the public what science has done, is doing, and can do, this country will greatly gain.

* "Discovery, or the Spirit and Service of Science."—By R. A. Gregory. 340 pages. 8 plates. 7½-in. × 5-in. (Macmillan & Co. Price 5/- net.)

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THE RICHEST-FIELD TELESCOPE.

By S. L. WALKDEN.

MANY users of telescopes have probably experienced their most exalted feelings of admiration of the heavens while sweeping aimlessly, with low powers, in the region of the Galaxy. The author has himself done so, and has thereby been led to speculate regarding the richest-field telescope, or telescope which, in an average random setting—preferably upon a galactic region—will show through its eyepiece the greatest number of distinct star images. It was therefore with feelings of pleasure that Messrs. Chapman and Melotte's Greenwich table of numbers of stars of various magnitudes in galactic regions was read on page 305 of "KNOWLEDGE" of last August; for, as will be seen, it supplied the very data required to give a practical turn to the speculations referred to.

It is easy to show that the richest-field telescope is that for which Δ / a^2 is a maximum, where Δ is the star density per square degree for all stars down to the faintest, just visible with the telescope, and a is the aperture in inches. In the information it gives, however, a tabular method of calculation has great advantages over calculations of merely critical conditions.

In Table 54 the first column states star magnitudes from the fifth down to the seventeenth. In the next column, headed Light of Star, the seventeenth-magnitude star is obviously taken as the unit of light, the brighter magnitudes being then $2{\cdot}512^1$, $2{\cdot}512^2$, $2{\cdot}512^3$, and so on, brighter than that unit. This 2·512 is the usual light-ratio of magnitudes, or $\sqrt[5]{100}$, for which reason the significant figures are seen to repeat themselves every five magnitudes. In the next column, headed Aperture in Inches, the standard assumption is seen to be made that the ninth-magnitude star is just perceived through a one-inch instrument, and the apertures for the other magnitudes are made to vary from that unit aperture inversely with the square root of the numbers printed in the preceding Light of Star column. That gives the accepted aperture values, though it underestimates the apertures for very faint stars, through not allowing for excessive light-absorption in very thick lenses.

The fourth column, headed Richest Magnifying Power, requires a somewhat lengthened explanation. Let us take the thirteenth-magnitude 6·31-inch telescope, and let us fit it with an eyepiece magnifying three hundred and fifteen diameters (fifty per inch of aperture), and having an *apparent* field of view of as much as fifty degrees diameter. If we direct that instrument at random, even near the galaxy, the average display will be found hardly so good as three stars, *looking* like

TABLE 54.

Magnitude of Star.	Light of Star.	Aperture in Inches.	Richest Magnifying Power.	Objective Field's Diameter (degrees).	Objective Field's Area (square degrees).	Total Stars down to given Magnitude per square degree near Galaxy.	Number of Stars visible in Field.	Stars per Magnitude-step per square degree.	Stars per Magnitude-step seen per View.	Sum of last column to Given Magnitude (light-units)	Mean Light of Visible Stars (light-units)	Apparent Magnitude of Mean Star.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
5	63100·000	0·159	0·539	92·8000	6760·0000	0·027	182·4	0·027	162·4	162·4	0·890	6·2
6*	25120·000	0·251	0·852	58·7000	2707·0000	0·102	276·0	0·075	202·9	365·3	1·322	6·0
7	10000·000	0·398	1·349	37·0700	1079·0000	0·359	387·5	0·257	277·5	642·8	1·660	5·8
8	3980·000	0·631	2·138	23·3700	429·0000	1·160	497·5	0·801	343·6	986·4	1·983	5·6
9	1585·000	1·000	3·390	14·7600	171·0000	3·510	600·0	2·350	401·7	1388·1	2·330	5·4
10	631·000	1·590	5·390	9·2800	67·6000	9·770	660·0	6·260	423·1	1811·2	2·746	5·3
11	251·200	2·510	8·520	5·8700	27·0700	25·400	687·5	15·630	423·2	2234·4	3·252	5·1
12	100·000	3·980	13·490	3·7070	10·7900	61·700	666·0	36·300	392·9	2627·3	3·945	4·9
13	39·800	6·310	21·380	2·3370	4·2900	141·000	604·8	79·300	340·0	2967·3	4·910	4·6
14	15·850	10·000	33·900	1·4760	1·7100	306·000	523·2	165·000	282·3	3249·6	6·210	4·4
15	6·310	15·900	53·900	0·9280	0·6760	631·000	426·6	325·000	219·6	3469·2	8·140	4·1
16	2·512	25·100	85·200	0·5870	0·2707	1245·000	337·0	614·000	166·1	3635·3	10·480	3·8
17	1·000	39·800	134·900	0·3707	0·1079	2399·000	258·9	1154·000	124·6	3759·9	14·520	3·5
* For naked-eye 6·36	18200·000	"telescopes":— 9·295	1·000	50·0000	1962·0000	about 0·160	about 315·0	—	—	—	—	5·9

This table has been calculated with sufficient accuracy by means of a slide-rule. The zeros added to preserve the appearance in print are not intended to imply accuracy beyond the third significant figures.

4·7-magnitude stars, but really of 11·3 magnitude, arranged, probably, in an open equilateral triangle,* To improve the richness of this field of view we shall have, of course, to use lower and lower powers, under which treatment the original triangle, while remaining perfectly distinct, will shrink in apparent size; and other stars will pass into view through the edges of the field, so as to increase the total number visible, at one setting, inversely with the square of the magnifying power. That increasing richness of field continues till we have reduced the magnifying power to 21·38 (or 3·39 per inch of aperture); but less than that we must not go, for the important reason now to be explained.

When the given telescope is pointed at a star, the star sends into the telescope a cylinder of light 6·31 inches in diameter, and, in accordance with the well-known property used in a common way of finding the magnifying power, the three hundred and fifteen-power eyepiece reduces that large cylinder of light into one only (6·31÷315), or 0·02 inch in diameter. This small cylinder, though only one fiftieth of an inch in diameter, contains all the original light less a negligible optical absorption, and easily enters the observer's eye. It easily enters the eye, because *in very dull light* the pupil is as much as 0·2953 inch in diameter. But when we have reduced the magnifying power so low as 21·38, we have raised the diameter of the eyepiece's emergent cylinder of light up to (6·31÷21·38), or exactly 0·2953 inch; so that if we were to use a lower power, the emergent cylinder would become *too large to enter the eye.* Only the centre of the object glass would then be in use, and the instrument, instead of being the intended 6·31-inch, would convert itself into *optical identity* with a smaller instrument on the list. The richest-field arrangement of telescopes of given apertures therefore consists in providing each one with a magnifying power of exactly the aperture in inches divided by the 0·2953 inch diameter of the pupil of the eye. Accordingly, that is the quantity printed in each line of the fourth column of the table.

The 0·2953 inch diameter of the pupil of the eye—the author's eye, but presumably an average one—is 7·5 millimetres, and was measured in the following way. A very small gas jet at one end of a room was viewed from the other end through one eye. A strip of paper, tapered from a width of five millimetres at one end to ten millimetres at the other, was then passed in front of the eye till the width was found that could just prevent the gas jet being seen. That width, 7·5 millimetres, was reasonably presumed to be the exact diameter of the pupil when fully expanded in a very dim light. Calculated in the table as a " telescope " of 0·2953 inch aperture, the naked eye, on the basis of one inch aperture showing a ninth-magnitude star, shows stars as faint as the 6·36 magnitude (see foot of Table 54). This agrees well enough with sighted authorities.

To see as many stars as possible at one observation, we naturally require the eyepiece to have as large an apparent field as possible consistent with satisfactory definition. As well-defined apparent fields of upwards of fifty degrees are now attainable in modern eyepieces, that figure has been adopted; and it has been divided, in each case, by the magnifying power, to give the fifth column's Objective Field of View, or degrees diameter of the circular portion of sky, which is being magnified by the telescope into appearing fifty degrees in diameter. These diameters squared, and then multiplied by $\pi/4$ (which is 0·7854), then give the areas of the objective fields of view, in square degrees, as printed in the sixth column of the table.

The important figures of the next or seventh column, stating the total number of stars per square degree of galactic regions down to the given magnitudes, are taken straight out of Dr. Crommelin's interesting article before referred to.

Since—taking an example—the ninth magnitude one-inch telescope has an objective field area (sixth column) of one hundred and seventy-one square degrees, and since all stars down to those it just makes perceptible have a density of 3·51 per square degree (seventh column), it is clear that that telescope shows 171×3·51, or six hundred, stars at one average view. The corresponding products of the sixth and seventh columns are therefore written in all the lines of the eighth column, headed Number of Stars Visible in Field.

Inspection of this eighth column at once tells us that the richest-field telescope which we set out to discover is no more than a modest two-and-a-half-inch one; for a *larger,* as well as a smaller, one actually shows a less number of stars in its field of view at one average observation. It should certainly be an acceptable encouragement to owners of the manageable two- to three-inch instruments to know that in at least one respect they have a unique advantage over those who only possess the giants. The advantage is naturally one that is most useful in studies relating to stellar groupings, or finding comparison stars, or where, as intimated before, the observer is only taking a pure delight in admiring the heavens in as *wholesale,* beautiful, and comprehensive manner as possible.

Now although, according to the precise measure adopted, the two-and-a-half-inch telescope is the richest-field one, and should, before all others, be so called, yet, even in the precise sense, the six-inch telescope is little inferior, while in most opinions the display in the larger instruments

* Found thus: A magnifying power of 21·38 (fourth column) shows 604·8 stars (eighth column), so a power of 315, with its smaller area of field, shows $(21{\cdot}38\div315)^2 \times 604{\cdot}8$, or 2·78, stars. These are of 4·6 magnitude (thirteenth column). When there chances to be the nearest whole number—three—of *equal* stars, the probability is that these will give the same total light, and so be of the slightly fainter 4·7 magnitude.

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is decidedly more attractive and "richer." This is apparently because most eyes esteem a considerably brighter appearance of the individual stars more than a small loss in the number visible at one setting. Since we are dealing here with matters of taste—some admire one Sirius-like star, where others prefer the same light distributed over a hundred fainter stars—we cannot again set up precise criteria. Nevertheless, as it seems likely enough that the artistic richness of the field is partly connected with the total light thrown into the eye by the stars whose images are distinctly perceived, the tabular calculations have been continued with that probability in view, although with no intention of detracting from the more precise and more serious conclusions reached in the eighth column.

In the seventh column we read that down to the seventeenth magnitude there are two thousand three hundred and ninety-nine stars per square degree of sky, and down to the sixteenth magnitude one thousand two hundred and forty-five stars per square degree. The difference of these numbers, or one thousand one hundred and fifty-four in the ninth column, is evidently the number of stars of between the sixteenth and seventeenth magnitudes per square degree of sky. Similarly, six hundred and fourteen in the ninth column, being the difference between the numbers one thousand two hundred and forty-five and six hundred and thirty-one in the seventh column, is the number of fifteenth- to sixteenth-magnitude stars per square degree of sky, and so to the top of the ninth column. It will be seen that the ninth column is suitably headed Stars *per Magnitude-step* per Square Degree of Sky.

In the tenth column the figure 124·6, being the product of 0·1079 in the sixth column and one thousand one hundred and fifty-four in the ninth, is plainly the number of sixteenth- to seventeenth-magnitude stars perceived at one view through the seventeenth magnitude, 39·8-inch telescope. Similarly, 166·1 in the tenth column, being the product of corresponding figures in the sixth and ninth columns, is the number of fifteenth- to sixteenth-magnitude stars seen at one view in the sixteenth magnitude 25·1-inch telescope; and so on to the top of column (10). The figures of this tenth column are seen to have a maximum; but that cannot be shown to demonstrate anything more important than that the tenth- to eleventh-magnitude stars contribute most of the starlight in any telescopic view of the heavens—a fact already well known.

The next column, the eleventh, in which the interest again increases, requires a little concentrated thought if what it signifies is to be understood. As already explained, the figure 124·6 at the bottom of the tenth column tells us that there are those many sixteenth- to seventeenth-magnitude stars visible at one average observation with the seventeenth magnitude, 39·8-inch telescope. Now these stars are at the limit of visibility through that telescope, so that if we adopt as our light-unit the light received by the eye from a star apparently at the limit of visibility (a unit of obviously the same value with the naked eye as with *any* telescope), we see that with the seventeenth magnitude, 39·8-inch telescope, the sixteenth- to seventeenth-magnitude stars seen in one observation send into the eye 124·6 units of light. Just in the same way, the sixteenth magnitude, 25·1-inch telescope, sends into the eye 166·1 of the same just-visible units of light, and so on up to the top of column (10). But what light units do the fifteenth- to sixteenth-magnitude stars, visible in the *seventeenth magnitude* 39·8-*inch telescope*, contribute to the eye? That is what we must proceed to find.

The number 166·1 in the tenth column represents, as stated, the light-units contributed by the fifteenth- to sixteenth-magnitude stars seen at one observation with the sixteenth-magnitude telescope. If we now look through the seventeenth-magnitude telescope, the same stars will, *if all seen*, contribute more light in the ratio of the areas, or the squares of the diameters, of the apertures; so that the figure 166·1 becomes $166{\cdot}1 \times (39{\cdot}8/25{\cdot}1)^2$, or four hundred and eighteen units of light. But, owing to the reduced field of view of the larger telescope, a proportionally less number of stars is only visible at one view; so, multiplying the four hundred and eighteen units by the ratio 0·1079/0·2707 taken from the sixth column, we find that the fifteenth- to sixteenth-magnitude stars *seen* contribute only 166·1 units of light in the seventeenth-magnitude telescope—just what they did in the sixteenth-magnitude one, and would do in an eighteenth- or nineteenth-magnitude one. There is no coincidence in the figures: the correction for the number of stars seen is necessarily the reciprocal of the correction for the light contributed by each star; one (the latter) is the ratio of the apertures squared; the other is the *inverse* ratio of the apertures squared, and so they cancel each other—that is all.

Since, therefore, the numbers down the tenth column represent alternatively the light-units contributed by the various magnitudes of stars in a view through the seventeenth-magnitude telescope, the sum of all those numbers, which is the 3759·9 at the bottom of the eleventh column, is the *total* light-units contributed by *all* stars distinctly seen at one average view through the seventeenth-magnitude telescope. Similarly, the sum of all the tenth column down to the last line but one—3635·3 in column (11)—is the total units of light contributed by all stars distinctly seen at one average view through the sixteenth-magnitude telescope, and so on.

The eleventh column may disappoint in having no maximum, but at about the fourteenth-

magnitude (ten-inch) telescope it shows so great a falling off in the rate of increase as to enable us to say that, *judged by the total starlight sent into the eye at one average view*, the richness of field of only a ten-inch telescope is not very greatly inferior to that of the forty-inch Yerkes instrument, even when no allowance is made for the absorption of light in the very thick lenses of the latter instrument.

However, many may not agree that the total starlight per field of view is a proper measure of the richness. For example, the 3249·6 units of light of the ten-inch telescope may be supplied either by three thousand two hundred and fifty just-perceptible, glittering points of light, like sparkling dust, or by twenty objects *looking* like first-magnitude stars ; and which is the "richer" field it is hard to say. These considerations suggest that the eye incorporates a measure of richness based on the light-units contributed per star visible. Those quantities are easily found by dividing the figures of the eleventh column by those of the eighth ; but as the number of light-units in each average star visible does not readily convey its import, the corresponding ordinary star magnitudes have been calculated by logarithms, assuming, as before found, that our light-unit—the star just perceptible by the eye—is always of apparent magnitude 6·36. The magnitudes so found are printed down the last column.

As showing the comprehensiveness of the information respecting star fields that is provided by the table, it may suffice to go through the example of the 2·51-inch telescope, column (3). From column (1) we read that the instrument just shows eleventh-magnitude stars, which—see column (2)—have 251·2 times the light of the seventeenth-magnitude stars, just visible in the 39·8-inch or forty-inch Yerkes instrument, columns (1) and (2). We then read that the 2·51-inch, when provided with its richest-field, or lowest, 8·52-power eyepiece, column (4), having a largest practicable objective field of 5·87 degrees diameter, column (5), and 27·07 square degrees area, column (6), shows an average of 687·5 stars in its galactic field of view, column (8). We next read that these stars send through the telescope and into the eye a total light equal to 2234·4 just-visible stars, column (11), the same as if the 687·5 stars were all composed of stars appearing as 5·1-magnitude stars do to the naked eye, column (13). By way of addendum, if we wish to compose the real probable field, we can easily do so by first charting down on a ten-inch paper disc, held twelve inches from the eye (apparent field then about fifty degrees), four hundred and twenty-three, column (10), just-visible stars, as if they were 6·4-magnitude naked-eye stars ; then 423·1, column (10), divided by 2·512, column (2), or one hundred and sixty-eight stars, one magnitude brighter, as if they were 5·4-magnitude naked-eye stars ; then 401·7, column (10), divided by 6·31, column (2), or six hundred and thirty-six stars, as if they were 4·4-magnitude stars, and so on, step by step from the *bottom* of column (2) as we step up from the proper line in column (10). The reasons for this method are more prolix to explain than they should be simple to discover.

It will be noticed that the top of the table tacitly assumes that all stars brighter than the fifth magnitude are not brighter than the fourth magnitude ; but when that convenient assumption is not made, the figures are substantially unaltered, because of the comparative rareness, telescopically, of stars brighter than the fourth magnitude. A correction to the areas in the sixth column, to allow for large areas of sky being sensibly spherical instead of flat, is also not made. This correction, being, however, only a five per cent. reduction for the top figure, two and a half per cent. for the next, one per cent. for the third, and practically nothing after that, is dismissed as of no account.

To conclude, the most important fact established is that, for sweeping in galactic regions, the richest-field telescope, showing the observer the greatest number of distinct, telescopically lucid star images at one average view, is only a two and a half-inch telescope ; and it does its best in that respect when fitted with an eyepiece, magnifying only eight and a half times, designed to have a field of view as large as possible.

NOTES.

ASTRONOMY.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

DR. CHARLIER'S MEMOIR ON THE B OR HELIUM STARS.—This memoir is an important contribution to our knowledge of the shape and size of our universe or Galaxy. The helium stars are of enormous intrinsic lustre, and are supposed to be of unusually great mass. This is indicated both by their very high temperature (the maximum temperature of a star being evidently a function of its mass) and by their small motions (there being strong reasons for concluding that the stars of small mass have, on the average, more rapid motion). It appears that the B stars do not differ very largely among themselves in intrinsic lustre, so that if we assume that they are all equally bright, and deduce the distances of the nearer ones, we can determine the distance of all of them from their apparent brightness. We may, of course, be wrong in a few cases, but the results from the mean of a large number of stars are likely to be correct. The point that makes this research of special value in the case of the helium stars is that they are of such enormous lustre that they remain fairly conspicuous objects, even if situated on the confines of our star-system. Thus a determination of the size and shape of the cluster of B stars is at the same time a determination of the size and shape of our universe. It is satisfactory that the results obtained are in fair accord with those deduced by other methods.

Dr. Charlier commences by tabulating the proper motions and radial velocities of the brighter stars of the B type.

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He deduces that the Sun moves twenty-one and a quarter kilometres per second relatively to them; that a B star of magnitude 0·00 is distant seventy-five light-years. Hence one of magnitude 5·0 is distant seven hundred and fifty light-years, and one of magnitude 10·0 seven thousand five hundred light-years. As a matter of fact, none are so faint as this, the faintest being of magnitude 8½, indicating a distance of two thousand four hundred light-years. The solar apex, or point towards which the Sun is moving, is found to be R.A. 18h. 9m., N. Decl. 31° 55′, between Hercules and Lyra. This agrees well with that found from other spectral types, and shows that the B stars have no peculiar motion relatively to the rest of our universe.

Rectangular coördinates are calculated for each star, and diagrams are given showing their projections on the three principal planes. The results indicate a shape like a bun for the system of stars. The plan, as seen from a point on the axis of the Milky Way, is more or less circular; but it is appreciably denser and more extended in the regions of Orion, Argo, and Centaurus than in those of Cygnus and Cassiopeia. The projections on the two other principal planes are both, roughly, oval in form, the major axis of the denser portion being three thousand light-years; the minor axis one-third of this. But there are many stragglers outside these limits.

One of the most interesting points is the determination of the centre of the group, as this may give a fair indication of the centre of the Galaxy itself. It is some two hundred and ninety light-years from the Sun in the direction of the constellation Carina, the Sun being sixty-three light-years to the north of the medial plane of the Galaxy. More exactly the centre is in R.A. 7h. 42m., S. Decl. 55° 37′. Sir John Herschel noted that this region was one of the most beautiful in the whole sky. The bright star Canopus, R.A. 6h. 22m., S. Decl. 52° 38′, is in this neighbourhood; but the very small values found for its parallax would indicate that it is not really near Dr. Charlier's centre, but is more remote. However, there is considerable uncertainty in such tiny parallaxes.

Achernar (α Eridani) is the nearest to us of the helium stars. Theory and parallax observations agree in assigning to it a distance of sixty-three light-years. The region opposite Charlier's centre is in Cygnus, and this is the direction in which we should expect the Galactic star clouds to be nearest to the Sun.

Miss Cannon has been at work at Harvard College on an immense catalogue of the spectra of about a quarter of a million stars, which I hear is approaching completion; when, it appears, it will be possible to see whether Dr. Charlier has included all the helium stars of our Galaxy, or whether there are others more remote than those which he has discussed. In any case, his position of the centre is not likely to be greatly modified.

I may mention that he uses the Siriometer (*i.e.*, one-million times the distance Earth–Sun) as his unit of stellar distance. It is 15·8 light-years, or 4·85 parsecs. The latter unit is coming into favour in England. It is the distance at which a star would have a parallax of 1″, and is 3·26 light-years.

Dr. Charlier also uses the stellar year (*i.e.*, a million ordinary years) as a unit of time for star movements. His units have some advantages, but I have reduced all his distances to light-years, as they are probably more intelligible in this form to our readers.

PROFESSOR BARNARD'S QUICK-MOVING STAR.—As the chart of the field of view of this star was not reproduced in my note in "KNOWLEDGE" for August, I give its position and those of some of its neighbours, from which readers may readily make charts to aid in identifying the Barnard star, denoted by q. I give the B.D. magnitudes and also those determined by Mr. W. H. Steavenson. q is of visual magnitude 9·5; photographic about 11. It is very red, being of spectral class M_b according to Professor Adams at Mount Wilson; M_a according to Professor Slipher at the Lowell Observatory. Their respective values for the speed of approach in the line of sight are ninety-one and forty kilometres per second. Professor Adams gives the parallax (deduced from the spectrum) as 0″·2, implying a distance of sixteen light-years. I am indebted to Professor Barnard for the Mount Wilson results, which are only given as provisional, and subject to revision after further observations.

B.D. Number.	Magnitude. B.D.	Magnitude. Steavenson	R.A. 1916·0. h.	m.	s.	N. Dec. 1916·0. °	′	″
4°·3554	9·0	9·1	17	52	20·2	4	14	10
·3555	9·5	10·9	17	52	21·3	4	19	28
·3556	8·0	8·0	17	52	37·6	4	23	16
·3559	9·5	9·7	17	53	19·0	4	34	37
·3560	8·7	8·7	17	53	34·4	4	26	55
q		9·5	17	53	43·5	4	27	50
·3561	9·4	9·9	17	53	47·0	4	15	20
·3562	9·5	9·5	17	54	15·4	4	28	13
·3570	5·3		17	56	6·1	4	22	21

3561 is the star called *d* in "KNOWLEDGE" for August. q must have been very near *d* in 1842, which will enable the track of its motion to be laid down. 3570 is the naked-eye star 66 Ophiuchi. The region will be badly placed till April, when it may be studied before dawn.

ENCKE'S COMET has been detected by Wolf, one month after aphelion passage, at a distance of four astronomical units from the Sun. The magnitude was 16½, the same as Halley's Comet when picked up in 1909. The place on September 22nd, 9h. 6m. 6s. *e* (Greenwich time), was R.A. 22h. 28m. 39s., S. Decl. 7° 8′ 5″. Attempts had previously been made at Yerkes Observatory to photograph Encke's Comet in aphelion. Some doubtful objects were photographed, but they were not certain enough to warrant an announcement.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C.

SELENSULPHUR FROM HAWAII.—Mr. G. V. Brown has examined a specimen of lava from Hawaii, in which were distributed yellow and orange-red crystalline particles, and has published the analysis in *The American Journal of Science* (1916, XLII, 132). These crystalline portions, when separated by hand from the crushed lava, were found to contain 0·68 per cent of selenium, 12·44 per cent. of sulphur, and 3·16 per cent. of moisture. This low proportion between the selenium and the sulphur pointed to the mineral being a "seleniferous sulphur" rather than selensulphur, which should consist of an isomorphous mixture of the two elements.

CITRIC ACID BY FERMENTATION.—Certain mould-fungi are capable of fermenting sugar into citric acid. One of the most active of these moulds is *Citromyces tollensianus*, which was discovered by Wehmer. The action of this or an allied species has recently been studied by Mr. J. A. Martin (*Amer. Journ. Pharm.*, 1916, LXXXVIII, 337). When a ten per cent. solution of dextrose, containing suitable salts, was inoculated with the spores of the mould and incubated at 20° C. in the presence of air, it soon became coated with a thin green film. The production of citric acid from the dextrose began after about five days, and reached its maximum (about twenty per cent. of the quantity of sugar) in a little more than three weeks. By neutralising the acid as it was formed by the addition of calcium carbonate at intervals, the yield could be increased to about forty-three per cent. of the original proportion of sugar. The essential conditions for the production of citric acid are that the solution shall be neutral, or only

slightly acid; that not more than ten per cent. of sugar shall be present; that the liquid shall contain nutrient salts; and that there shall be free access of air to promote the oxidation. Light has no influence on the results, but the fermentation is promoted by heat. It may be found possible to adapt this method of producing citric acid as an industrial process, the solutions of sugar being oxidised in shallow vessels exposed to a current of air. It would be difficult, however, to protect the cultivations from the attack of other moulds, many of which develop more rapidly than the species which produces citric acid.

OIL FROM THE KERNELS OF STONE FRUIT.—A new process of separating oil from the stones of fruits, such as cherries and plums, is described by Dr. K. Alpers in a recent issue of the *Chemiker Zeitung* (1916, XL, 645), and its general adoption is advocated as one means, among many, of supplying the dearth of oil in Germany. The cracked stones are treated, with a solution of calcium chloride, with a specific gravity of about 1·15. The shells fall to the bottom, while the kernels, which rise to the surface, are skimmed off, washed and dried, and the oil expressed. With regard to the possibility of the formation of hydrocyanic acid during the process, it is pointed out that only traces of the acid could be produced by cyanogenetic enzymes, since amygdalin is only sparingly soluble in such salt solutions. As a precautionary measure, however, it is advisable to renew the solutions frequently.

Oil thus prepared from plum-stone kernels had the taste and odour of bitter almonds, but was rendered nearly odourless by treatment with a current of steam. The same effect was also obtained by heating the oil or by exposing it for fourteen days to the air. The distillate from the treatment of one hundred grammes of the oil with steam contained four milligrammes of prussic acid. It is stated in a subsequent issue of the journal that an organisation of German women has undertaken the collection of cherry and plum stones for the purpose of extracting the oil from the kernels.

GEOGRAPHY.

By ALEXANDER SCOTT, M.A., D.Sc.

THE INFLUENCE OF JOINTING IN THE DEGRADATION OF THE LITHOSPHERE.—In a paper in *The Proceedings of the American Philosophical Society* (Volume LV) Ehrenfeld discusses the effect of jointing in the formation of earth-features. Numerous physiographers have considered jointing in their discussions of the lithosphere, but, in the opinion of this author, it has been regarded "as a phase of structural geology rather than as a controlling factor." The paper treats of the influence of jointing in connection with such physiographic features as coast-lines, river drainage, valley and fjord formation, plateau disintegration, and so forth, and numerous propositions are deduced from a detailed study of American localities. Jointing is held to be comparable with igneous action as a controlling factor, and its influence has been active in all geological formations. Phenomena such as surface drainage, glaciation, and weathering are more or less accidental, and it is the lines of fundamental weakness in the lithosphere, jointing and faulting, which are of paramount importance in the development of physiographical features. These lines of weakness are inherent in the lithosphere, and the degradation of the latter ensues by the action of transporting agents in the removal of "joint blocks." This influence is not confined to material above sea-level, for it is as important in marine denudation as in atmospheric weathering and erosion.

GEOLOGY.

VOLCANIC DOMES.—In *The American Journal of Science* for September, 1916, S. Powers describes five of these domes which have formed in the last few years since the famous dome and spine appeared on Montagne Pelée. Two of these arose in Japan and three on the Bogoslof volcano in the Behring Sea. The latter were all accompanied by the formation of a spine, and two of them were destroyed, after the interval of a few months, by explosions, showing that they contained gas at high pressure. A crater opened in the top of the third, allowing the gas to escape more slowly, so that it still exists. The rise of the domes on the Japanese mountains could be more carefully watched, and exact details are obtainable. One which rose in the crater of the volcano of Tarumai was formed as part of an ordinary eruption. In the year 1909, after an earthquake, ashes and lapilli were ejected from the crater while the lava was rising in the pipe. When the lava came into the crater a crust was formed, with the result that the uprising material pushed up the crust so formed into a dome. In about a fortnight it grew to a height of four hundred and forty feet, but later the centre settled down, leaving it lower, and with a flat top, in which form it remained, at any rate, till August, 1915. The elevation which occurred at the volcano of Usu was of rather a different nature. After several days of almost continuous earthquake shocks, a line of small craters was opened outside the old crater: when these had been active for some days, a block of land about one mile long and a thousand feet wide began to rise, and was finally raised to a maximum height of three hundred and ten feet above its original level in the course of three months (it afterwards sank one hundred and twenty feet). No lava came to the surface, but the block must have been pushed up by the intrusion of magma at a lower level. Minor instances of this phenomenon have been noted on the floors of the crater of Kilauea, and there are besides many ancient domes still remaining, such as the Puys of Auvergne. W. H. W.

TIN-MINING IN THE MALAY STATES.—Most of the tin mined in the Malay States is found in alluvial deposits, but some is now worked in place. The ores of two of the chief mines in the Main Granite Range are described, in an extract from an unpublished report of the Malay States Government, in *The Geological Magazine* for October, 1916. The whole of the district of the Ulu Bakau in the Granite Range is composed of granite, with pegmatite and greisen. The granite is medium-grained, "very rich in quartz, muscovite, and cassiterite, and relatively poor in felspar." In one mine there is abundant tourmaline and topaz, with little pyrites, or mispickel; but in the other the relative abundance is reversed in places, showing that in some areas the vapours of fluorine and boron played the chief part in the mineralising process, while in others those of sulphur and arsenic were more important. The ore is extracted in one mine from the undecomposed granite, which is crushed by foot-stamps before the cassiterite can be recovered. In the other mine cassiterite occurs in the granite, but it is chiefly worked from lodes cutting the massive rock. Only the richest "lode-stuff" is used, ore four to five times as rich as that now worked in Cornwall being thrown on to the dump heap. The chief object of the companies is to get as much tin as possible before a certain date, and, no doubt, the dumps will be worked over later.

W. H. W.

SCANDINAVIAN BOULDERS ON THE DURHAM COAST.—In a paper read before the Geological Society of London Mr. C. T. Trechmann has described an interesting glacial deposit in Eastern Durham. This deposit is found filling hollows and fissures in the magnesian limestone: it consists of a dark-coloured, compact clay, which becomes sandy in places, and contains, in addition to fragments of magnesian limestone, abundant boulders of Scandinavian rocks, including such well-known and unmistakable types as rhomb-porphyry, nordmarkite, and laurvikite; there are also many blocks of gneissose and schistose rocks and flints of a peculiar kind, which can only have come from Scandinavia. The deposit yields also a fair number of marine shells, which are clearly of boreal type, indicating the prevalence of arctic conditions. This deposit is overlain

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by another quite distinct glacial drift containing abundant Cheviot and Lake District rocks. This is obviously of purely British origin. The Scandinavian drift is closely comparable with the shelly basement clays of East Yorkshire, and shows that in Durham also the Scandinavian ice coming across the North Sea arrived on the eastern coast of England at an earlier date than the British ice coming from the north and west. This simple statement of fact, independent of speculations as to how the transport was effected, is of great interest, and may be of assistance in solving the more complicated problems presented by the drifts of Eastern and Central England. In the Eastern Midlands the earlier drifts have been so thoroughly ploughed up and incorporated in the later ones that it is extremely difficult to disentangle their relationships, and any attempt to draw conclusions from them as to the occurrence of interglacial periods seems almost hopeless. The best prospect of some light on this pressing problem of British geology seems to lie in the north, and it is to be hoped that the investigation will be extended into Northumberland, as was suggested in the discussion on the paper above mentioned. R. H. R.

AN ARCTIC FLORA AT CAMBRIDGE.—Dr. Marr and Miss Gardner have recently described in *The Geological Magazine* a most interesting discovery of plant remains embedded in peaty layers in a gravel at Barnwell, near Cambridge. This gravel deposit, which is clearly of very late Pleistocene date, lies a few feet below the level of the recent alluvium of the Cam, and contains an assemblage of plants recognised by Mr. Clement Reid as essentially similar to the well-known arctic plants of the Lea Valley at Ponders End, described by Mr. Hazzledine Warren. The plant-beds seem to belong to deposits filling a buried channel cut in the gravels of the older terraces, which have always hitherto been regarded as clearly post-Glacial. This observation is obviously of the greatest importance, as it indicates the recurrence of arctic conditions in this country at a date later than has hitherto been accepted. If arctic plants could then flourish on the lowlands of East Anglia, it is clear that glaciers must then have existed in the higher parts of this country, and the whole matter evidently has an important bearing on the possible occurrence of interglacial periods. It is highly desirable that the older gravels of other river-valleys should be searched for similar plant-bearing deposits. R. H. R.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

NATURE AND CAUSE OF BALL LIGHTNING.—At the Indian Science Congress held at Lucknow in January last Dr. G. C. Simpson, F.R.S., read a paper on "Some Problems of Atmospheric Electricity." In dealing with the nature and cause of ball lightning, he said that from the mass of evidence, which might almost be called chaotic, three characteristics appear to stand out with such prominence that they cannot be longer doubted: (*a*) The body or ball itself, which is able to retain its individuality as it moves through the air, appears to be composed of gas or matter in some novel luminous condition; (*b*) the balls appear to exist independently of any large electrical intensity, for they have been observed within closed rooms where large electrical fields are impossible, and have also been observed to pass in and out of parallel telegraph wires; (*c*) they appear to be associated, directly or indirectly, with large quantities of energy; for they have been observed to explode with violence, and have also been seen to fuse the overhead wire of an electric tramway. Until recently we had no knowledge of glowing gas except when associated with an existing discharge or a flame. Professor Strutt has, however, shown that by means of an electrical discharge a mass of nitrogen can be put into a state in which it continues to glow for some time after it has been removed from the field. Dr. Simpson says: "I cannot help believing that the body of the ball lightning is some gas made to glow in this way by the intense discharge of a lightning flash. Professor Strutt has pointed out to me serious difficulties of this explanation, and I can see others, but future work may remove them. In any case active nitrogen is the nearest physical phenomenon to ball lightning yet produced in our laboratories."

NEW WIRELESS STATION ESTABLISHED FOR METEOROLOGICAL PURPOSES.—A wireless station has been established on Dickson Island, at the mouth of the Yenisei, by an expedition, under the leadership of Dr. Kuchakov, for the purpose of sending meteorological telegrams to the Physical Observatory in Petrograd. The value of these telegrams will be felt chiefly in Siberia.

CONSTRUCTION OF A RAINFALL MAP.—In the recently published volume of *British Rainfall*, 1915, Dr. H. R. Mill has an article, on the "Rainfall of the Forth Valley," which is illustrated by a valuable map of average rainfall based upon records for the thirty-five years, 1878–1912. The valley of the Forth above Queensferry has an area of about nine hundred and thirty-one square miles, and has a general rainfall of fifty and a half inches. The rainfall varies from less than thirty inches round Queensferry to more than one hundred and ten inches on the mountains between Loch Voil and Loch Lomond. To deal statistically or cartographically with the observed figures from mountain rain-gauges without discussion and adjustment, Dr. Mill considers, would result in sheer confusion and waste of time and effort. The figures must be trusted only when they are consistent with each other and with the known distribution of rain in relation to configuration and prevailing wind. The principle of representing the distribution of rainfall on a map by means of isohyetal lines is exactly the same as that of representing vertical relief by means of contour lines. Where the observed figures are numerous it is easy to draw a line which leaves all values below a certain figure on one side, and all values above that figure on the other. In instances where observations are few it is impossible to obtain equal support for all parts of the line. Dr. Mill describes how he proceeds to draw the isohyetal lines under such circumstances, and says that experience shows that in some parts of the country the isohyetals on a particular type of land surface can be drawn from a sufficiency of data, and if a similar land feature occurs in another part of the country, with a similar prevailing wind, the lines may be sketched in hypothetically from data, that would in other circumstances prove inadequate, by taking advantage of the similarity of the two regions and drawing the lines by analogy. Experience is the only guide as to how far such methods may be trusted, and the result of much work of the kind has suggested the following general principles: (1) That there are no abrupt transitions in nature; in other words, if the rainfall at one point is seventy inches, and at another point a few miles away fifty inches, for the same period, there must be a rainfall of sixty inches at some point intermediate between the two. (2) The rainfall on the windward slope of a hill increases from the lower to the higher levels, although not necessarily at a uniform rate. (3) The rainfall on the leeward slope of a hill is frequently greater at some point on the slope than on the summit. (4) When two portions of land of similar configuration have the same exposure to the prevailing wind the distribution of rainfall upon them is similar. In dealing with a map of average rainfall the words "windward" and "leeward" must be interpreted with reference to the *prevailing* direction of the wind.

MICROSCOPY.

By F.R.M.S.

THE QUEKETT MICROSCOPICAL CLUB.—At the meeting on October 24th, 1916, a summary of a paper by Mr. W. Milne, "On the Bdelloid Rotifera of South Africa," was given. It contained descriptions of nineteen new species, four varieties, and one new genus. It is interesting to note that since his return Mr. Milne has found in

BRITISH SPECIES OF *TESTACELLA*.

T. maugei.

FIGURE 176.

T. haliotidea.

FIGURE 179.

T. scutulum.

FIGURE 182.

The animals extended.

FIGURE 177.

FIGURE 180.

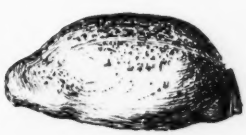

FIGURE 183.

The animals contracted and seen from the side.

FIGURE 178.

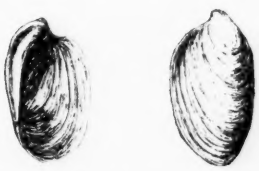

FIGURE 181.

FIGURE 184.

The shells enlarged.

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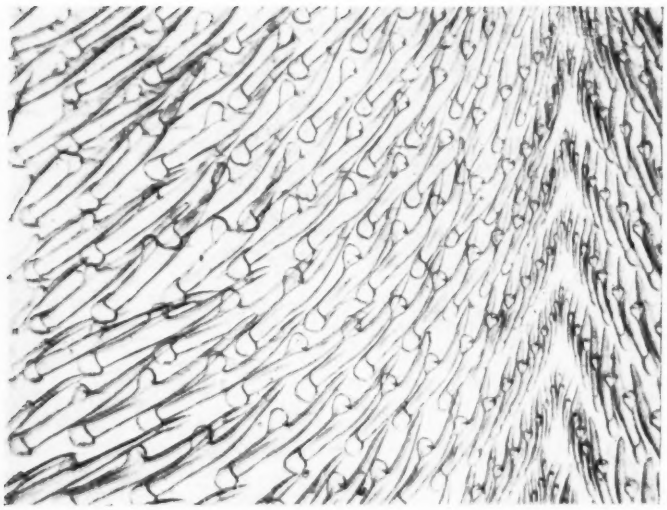

FIGURE 185.
A portion of the radula, unstained.

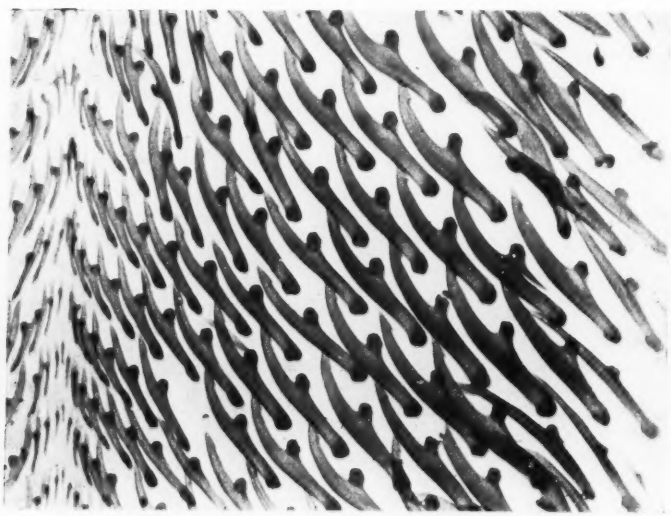

FIGURE 186.
The specimen seen in Figure 185, stained.

FIGURE 187.
Outline drawings of two teeth of *Testacella maugei*.

Figures 185 and 186 are from Photo-micrographs by E. W. Bowell.

Aberdeenshire three of the species which he had previously discovered in Cape Colony.

THE BRITISH SPECIES OF TESTACELLA.—Some years ago the present writer took considerable interest in the British species of *Testacella* (*Journal of Malacology*, Volumes IV to VI), particularly with a view to differentiating between *T. scutulum* and *T. haliotidea*, as these two worm-eating slugs could easily be mistaken one for the other. Moreover, the localities recorded for the latter were doubtful.

Mr. E. W. Bowell, knowing of this interest, not long ago kindly sent some photo-micrographs of the radulae, or lingual ribbons. The series of papers referred to was not completed, and, though drawings of the " teeth " had been prepared, they had not been published.

Those of *T. maugei* are now reproduced in Figure 187, and well show the barbs with which they are furnished for piercing and holding the worm when it is seized, and while it is being swallowed. Figures 185 and 186 are from photo-micrographs of the radula of this species. The first is from an untreated specimen, and the second from the same radula after it had been stained; the result in the latter case is very striking. It has been thought of interest to give illustrations of the external characters of the three slugs (see Figures 176 to 184). *T. maugei* is easily identified by the size of its shell and its stout body. In *haliotidea* the shell is not much larger comparatively than in *scutulum*, and the characters usually made use of in the field to distinguish these two species are the lines on the back. In the former these meet just underneath the margin of the shell, while in *scutulum* they come together just in front of it.

The writer found that when the creatures are retracted they have a characteristic profile (see Figures 177, 180, and 183). It is hoped to figure the radulae and teeth of the two last-mentioned species in the next number of " KNOWLEDGE."

W. M. W.

PHOTOGRAPHY.

By EDGAR SENIOR.

FURTHER NOTES ON ACID FIXING BATHS.—The same instability of the sulphur atom—which occupies the place of an atom of oxygen in sulphuric acid—that is observed when thiosulphates come in contact with salts whose metals form insoluble sulphides is noticeable in all plain solutions of " hypo " by the more or less rapid deposit of sulphur which takes place; and, while an acid sulphite may retard, it will not prevent, the deposit which the addition of a solution of plain sulphite will. Further, the addition of an acid salt will often prolong the time of fixation very considerably; thus, in the case of meta-bisulphite of potassium, the addition of one ounce of this to the pint of fixing bath will increase the time necessary for complete fixing by at least fifty per cent. Sodium sulphite added to the fixing bath also prolongs the time required for fixing, although not to the same extent. In fact, if we wish to add anything to the " hypo " fixing bath without greatly slowing its action, sodium sulphite is very useful when added in the proportion of one ounce to the pint of fixing solution, containing five ounces of " hypo " (twenty-five-per-cent. solution). If any increase in the rapidity of fixing is desired, it can only be gained by the addition of an alkali, or ammonium compounds, to the " hypo," or the use of a stronger fixing bath, a plain solution of " hypo " fixing at its quickest rate when it contains eight ounces of " hypo " in a pint of water (forty-per-cent. solution). When rapidity is gained by the addition of an ammonium compound the effect is due to the formation of ammonium thiosulphate, which is a more rapid fixing agent than the corresponding sodium salt. Messrs. Lumière and Sezewetz, however, found that negatives fixed in a solution of this kind contained very unstable silver compounds which could not be readily removed by washing. Then, again, ammonium thiosulphate is a very unstable compound when in solution, depositing sulphur very much more readily than the sodium salt does, and so increasing the risk of instability in the images fixed in it. The same thing might, of course, be expected to occur, " although to a less extent," with " hypo," if the latter is in a state of decomposition. Reviewing all the facts, the evidence evidently points to the advisability of not adding anything of an acid nature to the fixing bath, but to fix either in a plain or alkaline solution of " hypo," or one containing sulphite. As sulphite prevents decomposition, it would appear likely that ammonium sulphite added to the fixing bath would be a useful addition, since it should hasten the fixing action and at the same time act as a preservative.

REMOVING STAIN FROM NEGATIVES OR PRINTS.—Almost every variety of stain that is likely to be met with in either negatives or prints may be removed by the method due to Mr. R. E. Blake-Smith and described by him in *The British Journal of Photography*. The plan consists in first bleaching the image in a solution containing potassium permanganate, sodium chloride, and strong sulphuric acid, and afterwards redeveloping with amidol. For use the following stock solutions are prepared:—

No. I.

Potassium permanganate	10 grains
Water	5 ounces

No. II.

Sodium chloride	120 grains
Alum	120 ,,
Sulphuric acid (strong)	25 minims
Water	5 ounces

The actual bleaching solution is prepared from these by mixing two parts of No. I with four parts of No. II. The negative or print is first soaked in plain water, and then placed for ten minutes in a saturated solution of common alum, after which it is rinsed under a stream of water and then immersed in the bleaching solution, which acts very quickly. After bleaching a yellowish brown stain is found to have been imparted to the film, owing to the formation of oxide of manganese. This, however, may be removed by placing the negative or print after rinsing in the following:—

Alum	120 grains
Sodium sulphite	6 ,,
Sulphuric acid (strong)	5 minims
Water	5 ounces

When the stain has disappeared the negative, or print, is washed in running water for about ten minutes, and then the image redeveloped with an amidol developer, prepared according to the following formula:—

Amidol	6 grains
Sodium carbonate (crystallised) ...	6 ,,
Sodium sulphite (crystallised) ...	35 ,,
Water	2 ounces

After development is finished a final washing is given, and this completes all the operations.

ENLARGING WITHOUT A LENS.—A curious method of making enlargements by contact printing was recently communicated to the American Physical Society by Dr. A. J. Lotka. The process, which appears to have been worked out as the result of accidental observations, consists in first making a print from a negative illuminated by light passing through a very narrow slit, so that only a very narrow strip of the negative is printed at a time, as the negative is moved past the slit to expose each portion of it in turn, and while this is going on the material upon which the print is being made is also moved past the negative with a speed that bears some definite relation to the rate of movement of the negative itself. The effect upon the print is that, while the image is sharp and clear in one direction, all the lines in a direction at a right angle to this become drawn out in some fixed proportion. The print that is obtained is then subjected to a repetition of the entire process with the exception that the movement of the negative and support bearing the image is now made at right angles to the direction taken in making the first print, the result being that all lines which were drawn out

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in making the first print remain unaltered; while those at a right angle to them become in their turn drawn out. As this second image is enlarged in the opposite direction to the first, the result of the two enlargements is that an image is obtained which is enlarged, but without showing any distortion. Some very interesting examples of this method of enlarging were published recently in *The Scientific American*.

ABSORPTION OF ULTRA-VIOLET RAYS.—The action which radiations—known as ultra-violet rays, "though invisible to our eyes"—have in bringing about the photographic change in plates during exposure to light in the camera is now generally recognised; and, although dyes may be employed to render the emulsion orthochromatic or panchromatic, the sensitiveness of the silver salt to light of short wave-lengths still remains. On this account it is necessary that any screen that is employed to reduce the amount of blue and violet light transmitted should be of such a nature that it will at the same time completely eliminate all the ultra-violet rays. In the case of some of the screens it has been found that this could only be accomplished at the expense of greatly increased exposure of the plate in the camera, and more or less faulty rendering of the relative luminosities of the subject. Screens made with colourless bodies well known for their property of absorbing ultra-violet rays have been used at different times. Foremost among these stand quinine sulphate and aesculin, the latter being used in a dry state, and the former in solution in a cell. The result of some researches published in the *Comptes Rendus*, July 24th, 1916, by MM. Massol and Faucon, on the absorption of ultra-violet radiations by bromine derivations of methane, still further extend the number of bodies that may possibly be found useful in making light filters. The authors studied the absorption of ultra-violet radiations by bromine, carbon tetrabromide, tribromomethane, and also dibromomethane. The characteristic band of bromine in solution $\lambda 248 - \lambda 295$ was not found in any of the bromine derivatives of methane; while the less bromine they contained the more transparent the compounds were found to be towards ultra-violet radiations. Then, again, each bromine derivative was found to be less transparent than the corresponding chlorine derivative, each being examined under the same conditions as regard thickness and degree of concentration.

PHYSICS.

By J. H. VINCENT, M.A., D.Sc., A.R.C.S.

APPLICATION OF POLARISED LIGHT TO ENGINEERING.—For some years past Coker has been engaged in studying the optical effects produced by loading transparent celluloid models of engineering structures. Filon had also given attention to the subject by working with glass models. Mesnager has recently applied these principles to the case of a reinforced concrete bridge, which he designed to cross the Rhône at Balme. A glass model of the bridge was made cemented to a glass framework, and loads were applied by spring balances. The actual stresses were determined by the use of a graduated Babinet compensator in the polariscope. (*Engineering*, May 19th, 1916.)

AREQUIPA PYRHELIOMETRY.—Observations with the silver-disc pyrheliometer and nearly simultaneous measurements of atmospheric humidity have been made since August, 1912, at Arequipa, Peru, at the station of the Harvard College Observatory, eight thousand feet above sea level. The results are collected to give monthly mean values. These show a remarkably close connection between radiation and vapour pressure. Advantage is taken of this close connection to determine by empirical formulae values of the solar constant of radiation. These empirical values agree quite as well as could be expected with values obtained at Mount Wilson, California, by complete spectrobolometric and pyrheliometric measures combined. The Arequipa results confirm the variability of the Sun, both from year to year and from day to day, shown by investigations at Mount Wilson and elsewhere. It seems probable that from observations similar to those at Arequipa, if conducted at eight or ten favourable stations of high level in various parts of the world, the variations of the Sun could be determined almost, or quite, as certainly as from two stations equipped for complete spectrobolometric determinations of the solar constant. The Arequipa results indicate that the volcanic dust which was general in the atmosphere in the Northern Hemisphere for more than a year after the volcanic eruption of Mount Katmai, Alaska, in June, 1912, did not influence the transparency of the atmosphere in Peru.

COMPRESSIBILITY OF THE ATOMS.—The results of experimental investigations on the density and compressibility of elements and compounds are summarised by Richards in an address reported in *Science* for July 14th, 1916. The space occupied by the atom and molecule in solids and liquids is highly significant. The atomic volume is but slightly diminished by moderate mechanical pressures and by cooling even to absolute zero; but it is affected greatly by the mutual attractions of the atoms. The less volatile a substance the greater is its density and the less its compressibility; that is, greater cohesion is associated with greater compactness. Likewise powerful chemical affinity between the elements of a compound is associated with greater decrease of volume during the act of combination, and consequent increase in the density of the product. Thus both cohesion and affinity, by pulling the atoms together with enormous pressure, exert a compressing effect upon the atoms or upon the space they occupy. The result of either of these compressing agencies is found to be greater the greater the compressibility of the substances concerned.

THE KATA THERMOMETER.—Winslow (*Science*, May 19th, 1916) gives the results of investigations on the readings of this instrument and the corresponding degree of comfort experienced by observers who recorded their feelings of cold and warmth on an arbitrary scale. The Kata thermometer was invented by Hill to provide a means of estimating numerically the combined effect—temperature, humidity, and stillness—of the air. It consists of two thermometers with large bulbs and stems graduated from 86° to 110° F.: one to be read as a dry, and the other as a wet, bulb thermometer. The bulbs are heated to about 110° F., and then, while they are freely exposed, the time taken to fall from 100° to 90° is noted. Winslow finds that the instrument is of great value in measuring the influence of air conditions on the body. The conditions of maximum comfort are represented by the wet bulb taking from forty-five to sixty seconds to cool through the ten degrees, while the dry bulb takes about three times as long.

RADIO-ACTIVITY.

By ALEXANDER FLECK, D.Sc.

EFFECT OF α RAYS ON HYDROGEN.—Attention has been drawn in this column on various occasions to the chemical changes produced by the action of α rays. Most of these changes have been of the nature of decomposition of various compounds into their component elements. A different type of action has, however, been recorded by Duane and Wendt in *The American Physical Review* (Vol. VII, page 689). In this case the effect of the α rays is to act on hydrogen, and so form an allotropic modification of it. The evidence shows that this form possesses much greater power of chemical activity than is possessed by the gas prepared in the usual way. Hydrogen for the experiment was carefully purified, and then allowed to come into contact with a glass tube, which contained thirty-five millicuries of radium emanation, and of which the walls

were so thin that α rays could pass through them. It was found that the hydrogen so treated could act on flowers of sulphur to give easily detectable quantities of H_2S, that it would form the corresponding compound with arsenic, and that it would easily reduce permanganate. This modification is, however, very unstable, and no trace of it can be obtained if a greater time than one minute is allowed to elapse between the hydrogen being exposed to the α rays, and then coming into contact with the sulphur.

If the active hydrogen is passed through a spiral tube, immersed in liquid air, then no action with the sulphur takes place. The action is certainly not due to free hydrogen ions, because the amount of H_2S obtained was not at all affected by passing the hydrogen exposed to α rays through a strong electric field before coming into contact with the sulphur.

The authors make the suggestion that the modification of hydrogen, first discovered by Sir J. J. Thomson and often referred to as "ozonised hydrogen," or H_3, is identical with that formed by the action of α rays. The evidence as stated in the paper certainly seems consistent with that view. If this idea is correct, one would have expected that the active gas would have been condensed in liquid air, rendered stable at that low temperature, and so a comparatively large quantity of the gas might be obtained. It is not clear whether the authors endeavoured to carry out such an experiment.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

POSITION OF CAPE GOLDEN MOLE.—Though this remarkable animal is not rare in South Africa, it is not often seen, and it has not been much studied. A recent investigation of the young skull has led Dr. R. Broom to the upsetting conclusion that *Chrysochloris* is not allied to any of the small mammals which are usually grouped together as "Insectivora," and that it requires a distinct order (Chrysochloridea) for itself.

ALBINISM.—A total or partial absence of pigment occurs very widely among vertebrates. Dr. R. W. Shufeldt points out that it is illustrated by nearly every family of birds; by many mammals, *e.g.*, woodchuck, prairie marmot, musk-rat, bat, beaver, porcupine, and squirrel; by certain snakes, "horned toads," and other lizards, but not by chelonians; by salamanders and frogs; by brook-trout, flounders, eels, and carp. There seem to be groups of animals, however, which are exempt from the variation.

FISHES CARRYING THEIR EGGS.—There is not much parental care among fishes, for in them the economising of reproductivity has not more than begun. Where it does occur, however, the parental care exhibited by fishes is usually very interesting, and Mr. C. Tate Regan, of the British Museum, has recently referred to the variety of ways in which the eggs may be carried about: in the mouth (Arius, some Cichlidae), on the occiput (Kurtus), on the abdomen (Aspredo), and in a special brood-pouch (Syngnathidae, like the sea-horse).

WAY-FINDING IN ANTS.—The trend of recent work has been quite against the theory of a special sense of direction. Beautiful experiments go to show that in many cases the ants utilise scent and illumination to build up a knowledge of a locality. But there are some cases that indicate something more, and in a recent paper, V. Cornetz reässerts his view that ants have a delicate sense of their own deviations, a sense of changes in position—a sense of angulation. He does not think that space is to an ant what it is to man. Homogeneous to man, it may be heterogeneous to the ant.

INFLUENCE OF TEMPERATURE ON RATE OF DEVELOPMENT.—The eggs of house-flies usually hatch the day after they are laid, but the period between laying and pupation varies, according to Miss Saunders' recent observations, from six to sixteen days, and the period between laying and the emergence of flies from nine to twenty-five days. The higher temperature hastens development, but 38° C. is the limit. In blowflies the eggs usually hatch the day after they are laid, the maggots pupate in twelve to seventeen days, the flies emerge in twenty-six to thirty-five days.

ZOÖLOGICAL SURVEY OF INDIA.—We are glad to see that the Government of India have approved of a scheme, proposed by the Zoölogical and Anthropological Section of the Indian Museum, Calcutta, for a zoölogical survey. It is pointed out that the survey will indirectly benefit medicine and sanitation, and that the interest in Indian zoölogy has greatly increased in recent years. This has been to no small extent due to the energy and expertness of Dr. Nelson Annandale, Superintendent of the Zoölogical and Anthropological Section of the Indian Museum. It is a matter for congratulation that his services have been secured as Director of the Survey, and every naturalist will wish him success.

"GRIBBLES" ATTACKING SUBMARINE CABLE.—Professor Charles Chilton, of Canterbury College, New Zealand, reports a case where the boring crustaceans, known as "gribbles" (*Limnoria lignorum*), had burrowed into the gutta-percha covering the inner core of a submarine cable in Cook Strait. The perforations were at a place where a splice had been made. At other parts the armouring wire of the cable had prevented perforation. The cable was at a depth of about sixty fathoms and at a distance of 13·75 nautical miles from the entrance to Wellington Harbour, and of 4·75 nautical miles from the nearest land, Sinclair Head. The animal is often found attacking submerged timbers in harbours, but this case suggests an unexpected power of locomotion.

SHARK STORIES.—Dr. Frederick A. Lucas, Director of the American Museum of Natural History, has critically investigated many of the stories about the Great White Shark (*Carcharodon carcharias*) and the Blue Shark (*Prionace glauca*), and finds them badly exaggerated. Cases of "man-eaters" attacking bathers are very few except in tropical waters. One of the commonest statements that "the shark bit off the man's leg as though it were a carrot" cannot be accepted. Notwithstanding popular opinion to the contrary, a shark is not particularly strong in the jaws. Sharks twelve feet long have difficulty in tearing meat from the carcass of a whale. "I remember," Dr. Lucas writes, "my own disappointment at witnessing the efforts of a twelve-foot shark to cut a chunk out of a sea-lion. The sea-lion had been dead a week, and was supposedly tender, but the shark tugged and thrashed and made a great to-do over each mouthful." But a truly large White Shark, thirty feet long, with teeth over an inch long, is a formidable creature, and a blow of its tail may be as fatal as a bite.

PREJUDICED AESTHETIC APPRECIATION OF ANIMALS.—One of the difficulties of getting a genuine verdict in regard to the beauty of animals is, that even zoölogists often allow a quite extrinsic prejudice to warp their aesthetic judgment. Thus, in regard to sharks, which have always seemed to us to have great aesthetic merits, Messrs. Nichols and Murphy have recently written as follows: "There is something peculiarly sinister in the shark's make-up. The sight of his dark, lean fin, lazily cutting zigzags in the surface of some quiet, sparkling summer sea, and then slipping out of sight not to appear again, suggests an evil spirit. His leering, chinless face, his great mouth, with its rows of knife-like teeth, which he knows too well how to use on the fisherman's gear, the relentless fury with which, when his last hour has come, he thrashes on deck, and snaps at his enemies; his toughness, his brutal, nerveless vitality and insensibility to physical injury, fail to elicit the admiration one feels for the dashing, brilliant, destructive, gastronomic bluefish, tunny, or salmon." *De gustibus non disputandum est!*

XUM

THE FACE OF THE SKY FOR DECEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 55.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Dec. 1	16 29·1	S. 21·8	22 9·1	S. 7·8	16 46·1	S. 23·7	14 10·9	S. 11·1	1 38·8	N. 8·8	8 9·9	N. 20·2	8 28·1	N. 18·9
„ 6	16 50·8	22·5	2 19·4	N. 19·1	17 20·1	24·8	14 34·6	13·2	1 37·7	8·7	8 9·1	20·3	8 27·8	18·9
„ 11	17 12·8	23·0	6 48·3	N. 23·8	17 54·5	25·5	14 58·7	15·1	1 36·8	8·6	8 8·1	20·3	8 27·4	18·9
„ 16	17 34·9	23·3	10 41·1	N. 4·0	18 29·1	25·5	15 23·3	16·8	1 36·4	8·6	8 7·0	20·4	8 27·0	18·9
„ 21	17 57·0	23·4	14 40·9	S. 20·7	19 3·2	24·9	15 48·4	18·4	1 36·2	8·6	8 5·7	20·5	8 26·6	18·9
„ 26	18 19·3	23·4	19 57·5	S. 20·0	19 35·6	23·7	16 14·0	19·8	1 36·3	8·7	8 4·3	20·5	8 26·1	19·0
„ 31	18 41·4	S. 23·1	0 26·5	N. 8·5	20 4·0	S. 21·9	16 40·1	S. 21·0	1 36·8	N. 8·7	8 2·7	N. 20·6	8 25·6	N. 19·0

TABLE 56.

Date.	Greenwich Noon. Sun. P	Sun. B	Sun. L	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2	Midnight. Moon. P
	°	°	°		°	°	°	h. m.	h. m.	
Dec. 1 ...	+16·1	+0·7	211·2	Dec. 4 ...	−22·6	+3·0	277·2	290·7	4 26 *m*	3 59 *m*	Dec. 1	−20·8
„ 6 ...	14·0	+0·1	145·3	„ 11 ...	22·7	3·0	302·3	262·5	3 45 *m*	4 46 *m*	„ 6	−18·1
„ 11 ...	11·9	−0·6	79·4	„ 18 ...	22·7	2·9	327·3	234·0	3 4 *m*	5 33 *m*	„ 11	+ 5·7
„ 16 ...	9·6	1·2	13·5	„ 25 ...	−22·7	+2·9	352·1	205·4	2 23 *m*	6 21 *m*	„ 16	+21·8
„ 21 ...	7·3	1·8	307·6								„ 21	+16·4
„ 26 ...	4·9	2·4	241·8								„ 26	−12·4
„ 31 ...	+ 2·5	−3·0	175·9								„ 31	−22·8

P is the position angle of the North end of the body's axis measured eastward from the North point of the disc. B, L are the helio-(planeto-) graphical latitude and longitude of the centre of the disc. T is the time of transit of the zero meridian across the centre of the disc. In the case of Jupiter, System I refers to the rapidly rotating equatorial zone; System II to the temperate zones which rotate more slowly. To find intermediate passages of the zero meridian of either system across the centre of the disc, apply to T_1 T_2 multiples of $9^h\ 50^m{\cdot}5$, $9^h\ 55^m{\cdot}7$ respectively.

The data for the Moon in Table 56 are given for Greenwich midnight, *i.e.*, the midnight at the end of the given day. Those for the planets were given for midnight last year, but are now given for Noon.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN is moving Southward with slackening speed till 22d 4^h *m* when it passes the winter solstice and commences to move northward. Its semi-diameter increases from 16′ 15″ to 16′ 18″. Sunrise changes from $7^h\ 46^m$ to $8^h\ 8^m$; sunset from $3^h\ 52^m$ to $3^h\ 58^m$. There is now considerable solar activity, and a constant watch should be kept on the disc. There is a very small eclipse of the Sun on Dec. 24th, visible for a small region of the Antarctic Ocean, south of the Cape of Good Hope.

MERCURY is an evening star. Semi-diameter increases from 2½″ to 3″. Illumination full at beginning of month, ⅔ at end.

VENUS is a morning star. The semi-diameter diminishes from 7″ to 6″. Illumination of disc increases from ⅘ to ⅞.

THE MOON.—First quarter 2d $1^h\ 55^m$ *m*; Full 9d $0^h\ 44^m$ *e*. Last quarter 17d $6^h\ 6^m$ *e*. New 24d $8^h\ 31^m$ *e*. First Quarter 31d $0^h\ 7^m$ *e*. Apogee 13d 9^h *e*. Perigee 26d 1^h *m*. Semi-diameter 14′ 45″, 16′ 40″ respectively. Maximum librations 5d 7° S., 5d 6° W., 19d 7° N., 20d 7° E., Jan. 1d 7° S., Jan. 1d 7° W. The letters indicate the region of the Moon's limb brought nto view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon. (See Table 59.) Attention is called to the fact that the maximum librations in longitude and latitude now occur nearly simultaneously.

MARS is low in the West and practically invisible.

JUPITER is in Aries; stationary on the 21st, Equatorial diameter 44″, Polar 41″. Defect of illumination ⅘″ at end of month.

Configuration of satellites at 9^h *e* for an inverting telescope.

JUPITER'S SATELLITES.

Day.	West.	East.	Day.	West.	East.
Dec. 1	4 ○	132	Dec. 17	42 ○	13
„ 2	412 ○	3	„ 18	41 ○	32
„ 3	24 ○	13	„ 19	43 ○	12
„ 4	13 ○	42	„ 20	3214 ○	
„ 5	3 ○	124	„ 21	32 ⊙	4
„ 6	32 ○	4 1●	„ 22	○	1324
„ 7	312 ○	4	„ 23	1 ○	234
„ 8	○	1324	„ 24	2 ○	134
„ 9	12 ○	34	„ 25	1 ○	234
„ 10	2 ○	134	„ 26	3 ○	124
„ 11	1 ○	324	„ 27	321 ○	4
„ 12	34 ○	12	„ 28	32 ○	14
„ 13	3421 ○		„ 29	4 ○	2 13●
„ 14	4321 ○		„ 30	41 ○	23
„ 15	4 ○	132	„ 31	42 ○	13
„ 16	41 ⊙	3			

The following satellite phenomena are visible at Greenwich:—2d $4^h\ 30^m$ *e* II. Tr. E., $6^h\ 24^m$ *e* II. Sh. E.; 4d $6^h\ 31^m$ *e* III. Tr. I., $8^h\ 11^m$ *e* III. Tr. E., $10^h\ 27^m$ *e* III. Sh. I.; 5d $0^h\ 10^m$ *m* III. Sh. E., $1^h\ 1^m$ *m* I. Oc. D., $10^h\ 11^m$ *e* I. Tr. I., $11^h\ 10^m$ *e* I. Sh. I.; 6d $0^h\ 20^m$ *m* I. Tr. E., $1^h\ 19^m$ *m* I. Sh. E., $3^h\ 8^m$ *m* II. Tr. I., $7^h\ 28^m$ *e* I. Oc. D., $10^h\ 39^m\ 29^s$ *e* I. Ec. R.; 7d $4^h\ 38^m$ *e* I. Tr. I., $5^h\ 39^m$ *e* I. Sh.

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TABLE 57.

Day.	α Andromedae. N. Dec. 28° 38′.	α Arietis. N. Dec. 23° 4′.	Aldebaran. N. Dec. 16° 21′.
	h. m. s.	h. m. s.	h. m. s.
Nov. 25	7 46 27·17 *e*	9 44 32·18 *e*	0 12 48·02**m*
Dec. 5	7 7 7·94 *e*	9 5 13 04 *e*	11 33 29·03 *e*
„ 15	6 27 48·70 *e*	8 25 53·88 *e*	10 54 10·00 *e*
„ 25	5 48 29.44 *e*	7 46 34·67 *e*	10 14 50·92 *e*

* Morning of November 26.

I., $6^h\ 47^m$ *e* I. Tr. E., $7^h\ 48^m$ *e* I. Sh. E., $9^h\ 23^m$ *e* II. Oc. D.; $8^d\ 1^h\ 58^m\ 12^s$ *m* II. Ec. R., $5^h\ 8^m\ 20^s$ *e* I. Ec. R.; $9^d\ 4^h\ 20^m$ *e* II. Tr. I., $6^h\ 28^m$ *e* II. Sh. I., $6^h\ 54^m$ *e* II. Tr. E., $9^h\ 2^m$ *e* II. Sh. E.; $11^d\ 10^h\ 3^m$ *e* II. Tr. I., $11^h\ 48^m$ *e* III. Tr. E.; $12^d\ 2^h\ 29^m$ *m* III. Sh. I., $2^h\ 50^m$ *m* I. Oc. D.; $13^d\ 0^h\ 0^m$ *m* I. Tr. I., $1^h\ 5^m$ *m* I. Sh. I., $2^h\ 9^m$ *m* I. Tr. E., $9^h\ 17^m$ *e* I. Oc. D.; $14^d\ 0^h\ 35^m\ 11^s$ *m* I. Ec. R., $6^h\ 27^m$ *e* I. Tr. I., $7^h\ 34^m$ *e* I. Sh. I., $8^h\ 36^m$ *e* I. Tr. E., $9^h\ 43^m$ *e* I. Sh. E., $11^h\ 46^m$ *e* II. Oc. D.; $15^d\ 4^h\ 27^m\ 15^s$ *e* III. Ec. D., $6^h\ 11^m\ 24^s$ *e* III. Ec. R., $7^h\ 4^m\ 3^s$ *e* I. Ec. R.; $16^d\ 4^h\ 12^m$ *e* I. Sh. E., $6^h\ 47^m$ *e* II. Tr. I., $9^h\ 7^m$ *e* II. Sh. I., $9^h\ 21^m$ *e* II. Tr. E., $11^h\ 40^m$ *e* II. Sh. E.; $18^d\ 5^h\ 52^m\ 59^s$ *e* II. Ec. R.; $19^d\ 1^h\ 40^m$ *m* III. Tr. I.; $20^d\ 1^h\ 50^m$ *m* I. Tr. I., $11^h\ 8^m$ *e* I. Oc. D.; $21^d\ 8^h\ 18^m$ *e* I. Tr. I., $9^h\ 29^m$ *e* I. Sh. I., $10^h\ 27^m$ *e* I. Tr. E., $11^h\ 38^m$ *e* I. Sh. E.; $22^d\ 2^h\ 12^m$ *m* II. Oc. D., $5^h\ 22^m$ *e* III. Oc. R., $5^h\ 35^m$ *e* I. Oc. D., $8^h\ 29^m\ 20^s$ *e* III. Ec. D., $8^h\ 59^m\ 48^s$ *e* I. Ec. R., $10^h\ 12^m\ 53^s$ *e* III. Ec. R.; $23^d\ 3^h\ 58^m$ *e* I. Sh. I., $4^h\ 55^m$ *e* I. Tr. E., $6^h\ 7^m$ *e* I. Sh. E., $9^h\ 15^m$ *e* II. Tr. I., $11^h\ 45^m$ *e* II. Sh. I., $11^h\ 50^m$ *e* II. Tr. E.; $25^d\ 8^h\ 29^m\ 47^s$ *e* II. Ec. R.; $28^d\ 1^h\ 0^m$ *m* I. Oc. D., $10^h\ 9^m$ *e* I. Tr. I., $11^h\ 25^m$ *e* I. Sh. I.; $29^d\ 0^h\ 19^m$ *m* I. Tr. E., $1^h\ 33^m$ *m* I. Sh. E., $7^h\ 13^m$ *e* III. Oc. D., $7^h\ 28^m$ *e* I. Oc. D., $9^h\ 10^m$ *e* III. Oc. R., $10^h\ 55^m\ 33^s$ *e* I. Ec. R.; $30^d\ 0^h\ 31^m\ 20^s$ *m* III. Ec. D., $4^h\ 38^m$ *e* I. Tr. I., $5^h\ 54^m$ *e* I. Sh. I., $6^h\ 47^m$ *e* I. Tr. E., $8^h\ 2^m$ *e* I. Sh. E., $11^h\ 47^m$ *e* II. Tr. I.; $31^d\ 5^h\ 24^m\ 32^s$ *e* I. Ec. R. Eclipses of the satellites take place low right of the disc, taking the direction of the belts as horizontal.

SATURN is a morning star in Cancer; has begun to retrograde; near Moon on morning of 13th. Polar semi-diameter 9½″. Major axis of ring 46″, Minor 16″. Angle P −7°·3.

East Elongations of Tethys (every fourth given) $2^d\ 11^h\cdot6$ *m*, $10^d\ 0^h\cdot8$ *m*, $17^d\ 1^h\cdot9$ *e*, $25^d\ 3^h\cdot1$ *m*; of Dione (every third given) $2^d\ 4^h\cdot1$ *e*, $10^d\ 9^h\cdot1$ *e*., $19^d\ 2^h\cdot0$ *m*., $27^d\ 7^h\cdot0$ *m*.; of Rhea (every second given) $8^d\ 9^h\cdot9$ *m*,, $17^d\ 10^h\cdot6$ *m*, $26^d\ 11^h\cdot3$ *m*. For Titan and Japetus E., W. denote East and West Elongations; S., I. Superior and Inferior Conjunctions. Titan $6^d\ 10^h\cdot6$ *e* E., $14^d\ 2^h\cdot8$ *e* W., $22^d\ 8^h\cdot3$ *e* E., $30^d\ 0^h\cdot3$ *e* W. Japetus $1^d\ 11^h\cdot3$ *e* W., $21^d\ 8^h\cdot6$ *m* S.

URANUS is an evening star in Capricornus; too near the Sun for convenient observation.

NEPTUNE is a morning star in Cancer: stationary on 7th. Near Moon at noon on 13th.

EROS.—This little planet will be in perihelion in December, and may be observed in small telescopes, being of the ninth or the tenth magnitude. The following ephemeris has been computed by Mr. F. E. Seagrave. It is for Greenwich midnight (that at the end of the day named).

Date.	R.A.	Decl.	Log. Dist. from	
	h. m. s.	° ′	Sun.	Earth.
1916. Dec. 11	11 54 2	N. 2 24	0·0543	9·8543
,, ,, 19	12 17 0	S. 2 27	0·0545	9·8435
,, ,, 27	12 39 13	7 18	0·0558	9·8334
1917. Jan. 4	13 0 46	12 4	0·0583	9·8241
,, ,, 12	13 21 38	16 43	0·0620	9·8150
,, ,, 20	13 41 49	S. 21 11	0·0667	9·806

GREENWICH TIMES OF MERIDIAN TRANSIT OF CERTAIN BRIGHT STARS.—These are given to facilitate the determination of time by observations with small transit instruments.

TABLE 58. LONG-PERIOD VARIABLE STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m. s.	° ′		d.	
S Ceti	0 19 44	− 9 48	7·3 to 13·6	321	1916—Nov. 29
o Ceti (Mira)	2 15 3	− 3 21	2·0 to 9·6	331	,, Dec. 4
R Ceti	2 21 42	− 0 34	7·0 to 13·0	167	1917—Jan. 3
T Arietis	2 43 35	+17 9	7·4 to 9·7	313	1916—Dec. 23
X Camelop.	4 34 29	+74 58	7·3 to 13·1	142	1917—Jan. 14
R Leporis	4 55 44	−14 56	6·0 to 10·4	436	,, Jan. 2
R Canum Venat... ...	13 45 18	+39 58	7·4 to 12·2	328	,, Jan. 8
R Camelop.	14 23 35	+84 13	7·2 to 13·3	270	1916—Dec. 31
T Herculis	18 5 53	+31 0	6·9 to 13·3	165	,, Dec. 11
AF Cygni	19 27 40	+45 58	6·9 to 8·0	99	,, Dec. 11
V Cygni	20 38 34	+47 50	6·8 to 13·8	418	,, Dec. 4
T Cephei	21 8 22	+68 9	5·2 to 10·8	387	,, Dec. 28
R Pegasi	23 2 23	+10 5	6·9 to 13·0	377	,, Dec. 30
R Aquarii	23 39 26	−15 45	6·0 to 10·8	387	,, Dec. 15

Minima of Algol $3^d\ 1^h\cdot8$ *m*, $5^d\ 10^h\cdot6$ *e*, $8^d\ 7^h\cdot4$ *e*, $11^d\ 4^h\cdot2$ *e*, $23^d\ 3^h\cdot5$ *m*, $26^d\ 0^h\cdot3$ *m*, $28^d\ 9^h\cdot1$ *e*, $31^d\ 5^h\cdot9$ *e*.
Period $2^d\ 20^h\ 48^m\cdot9$.

Principal Minima of β Lyrae $7^d\ 2^h\cdot4$ *m*, $20^d\ 0^h\cdot5$ *m*. Period $12^d\ 22^h\cdot1$.

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The times for intermediate days may be obtained by simple interpolation. The Greenwich time of the stars crossing the meridians of other places may be obtained by expressing the longitude of these places in time, diminishing them by 9s·83 per hour, and proportionately for fractions of an hour, then applying the result to the tabular time—positively for West longitudes, negatively for East ones. (See Table 57.)

Observers who know Greenwich Time can use the Table to obtain their South Point.

SUN before clock December 1, 654s·17; December 6, 534s·34; December 11, 401s·71; December 16, 259s·37; December 21, 111s·0; after clock December 26, 39s·04; December 31, 185s·94. These are the equations of time for the moment of solar transit at Greenwich.

VARIABLE STARS.—Stars reaching their maxima in or near November, 1916, are included. The lists in recent months may also be consulted. (See Table 58.)

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
Nov. 25–Dec. 12	189°	+ 73°	Rather swift.
Dec. 4 ...	162	+ 58	Swift, streaks.
,, 6 ...	80	+ 23	Slow, bright.
,, 8 ...	145	+ 7	Swift, streaks.
,, 8 ...	208	+ 71	Rather swift.
,, 10–12 ...	108	+ 33	Swift, short. Conspicuous shower.
,, 12 ...	119	+ 29	Rather swift.
,, 22 ...	194	+ 67	Swift, streaks.
,, 21–22 ...	117	+ 47	Swift.
,, 31 ...	92	+ 57	Slow, bright.

TABLE 59. Occultations of Stars by the Moon, visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Time.	Disappearance. Angle from N. to E.	Reappearance. Time.	Reappearance. Angle from N. to E.
1916.			h. m.	°	h. m.	°
Dec. 1 ...	170 B Aquarii	6·0	3 41 *e*	66	4 52 *e*	229
,, 2 ...	22 B Piscium	6·4	9 52 *e*	91	10 46 *e*	207
,, 3 ...	9 Piscium	6·4	0 15 *m*	26	—	—
,, 6 ...	μ Arietis	5·7	7 16 *e*	104	8 14 *e*	208
,, 7 ...	ε Arietis (double)	4·6	4 44 *m*	50	5 30 *m*	294
,, 7 ...	WZC 207	6·7	7 38 *e*	62	—	—
,, 8 ...	WZC 228	6·6	2 43 *m*	48	—	—
,, 8 ...	BAC 1186	6·4	2 58 *m*	85	—	—
,, 8 ...	BD +23°·569	6·8	3 12 *m*	54	—	—
,, 8 ...	62 Tauri	6·1	4 0 *e*	113	4 44 *e*	221
,, 8 ...	BD +24°·674	6·8	11 57 *e*	57	—	—
,, 9 ...	118 Tauri	5·4	8 46 *e*	112	9 53 *e*	239
,, 10 ...	132 Tauri	5·0	7 40 *m*	121	8 13 *m*	228
,, 11 ...	Lalande 12660	6·9	—	—	6 26 *m*	273
,, 11 ...	WZC 500	7·4	—	—	9 37 *e*	205
,, 11 ...	δ Geminorum	3·5	11 26 *e*	109	0 47 *m**	277
,, 12 ...	149 B Geminorum	6·4	3 53 *m*	98	5 6 *m*	306
,, 12 ...	63 Geminorum	5·3	4 27 *m*	99	5 38 *m*	305
,, 13 ...	54 Cancri	6·3	8 15 *e*	102	9 15 *e*	289
,, 14 ...	BD +11°·2071	7·0	—	—	10 31 *e*	315
,, 15 ...	155 B Leonis	6·5	—	—	11 3 *e*	293
,, 16 ...	WZC 699	7·2	—	—	4 54 *m*	351
,, 22 ...	153 B Librae	6·3	6 15 *m*	128	7 17 *m*	269
,, 27 ...	BD −15°·5908	6·3	4 23 *e*	31	—	—
,, 28 ...	WZC 1476	7·0	5 48 *e*	20	—	—
,, 31 ...	136 B Piscium	6·5	3 59 *e*	67	5 12 *e*	230

From New to Full, Disappearances occur at the Dark Limb; from Full to New, Reäppearances.
The asterisk indicates the day following that given in the date column.

LARVAE OF THE TIGER BEETLE (*CICINDELA CAMPESTRIS*).

NOTES AND PHOTOGRAPHS—By HUGH MAIN, B.Sc.

I FOUND a number of larvae of the tiger beetle in the bank at the side of a Sussex lane last July. The situation was a very favourable one for observing them and also, as it was more than three miles from the coast, for photographing them. They were all on the sunny side of the road, and their shafts frequently occurred in pairs. Some of the holes were quite small (see Figure 190), and evidently contained larvae in their first year, resulting from ova deposited in the spring. The larvae in these small holes were very shy, or not hungry, as they rarely appeared at the top. There were few small holes compared with the number of large ones. The white sand thrown out by the larvae made the positions of the shafts very obvious, and they were noticed in most parts of the bank not overgrown by the hedge, wherever there was a small piece of level ground, and the moss or grass was not too thick (see Figure 189).

The larger larvae (which I took to be in their second year) came frequently to the surface, but some were much bolder than others, and would remain up for long periods, only retreating for a short time when alarmed (see Figure 190). When captured flies were placed at the entrance of a shaft

BURROWS OF THE TIGER BEETLE LARVA.

FIGURE 188.

The top of the shaft of the larva of the first year.

FIGURE 189.

The top of the shaft of the larva of the second year.

FIGURE 190.

One larva up at the top of the shaft.

FIGURE 191.

A vertical section of the shaft with the larva and its larder below.

From Photo-micrographs by Hugh Main, B.Sc. All natural size.

FIGURE 192.

An overturned Iceberg photographed by flashlight in the Antarctic.

FIGURE 193.

Captain Scott in his Cubicle.

From photographs by Herbert G. Ponting.

they suddenly disappeared, being dragged down by the tiger beetle larva, which soon put its head up at the top again, as if asking for more. The interval between disappearance and reappearance was so short I felt sure that the flies had not been consumed. On carefully opening up the shaft the flies were seen in the "larder" at the bottom, with the larva resting just above them (see Figure 191).

MR. PONTING'S PHOTOGRAPHS OF THE ANTARCTIC.

MR. HERBERT G. PONTING is again lecturing in London on Captain Scott's Antarctic Expedition, and using as illustrations many pictures which he has not shown before.

His fascinating narrative, no less than his exceptionally fine films and photographs, will appeal to everyone who has any pride in British intrepidity. Furthermore, there is a special scientific interest and value in his records, an artistic beauty about many of his successful pictures, which, it must be remembered, were taken in a temperature many degrees below zero; and, in addition, there is Mr. Ponting's own personality.

It is not given to everyone to witness the birth of an iceberg, but Mr. Ponting has seen and photographed one of these huge masses of ice breaking away from the parent glacier. Few have had many feet of ice broken beneath them by killer-whales. No one has before described, let alone shown with the kinematograph, the way in which Weddell seals clear away the ice with their teeth when they want to land on a floe to sleep.

There are, besides, hosts of interesting incidents, without considering the work of the expedition as a whole. Two pictures we are permitted to reproduce here: a portrait of Captain Scott and an overturned iceberg taken by flashlight (see Figures 192 and 193).

CORRESPONDENCE.

THE PERIODICITY OF THE CITY OF COMETS.

To the Editors of "KNOWLEDGE."

SIRS,—In reading Pepys's Diary I find several references to the Comet of 1664, the dates being December 17th, 21st, and 24th. But what particularly interested me, however, was the entry on March 1st, 1665, as follows:—

"To Gresham College, where Mr. Hooke read a second very curious lecture about the late comet; among other things proving very probably that this is the very same comet that appeared before in the year 1618, and that in such a time probably it will appear again, which is a very new opinion, but all will be in print."

My impression has always been that Halley was the originator of the theory that comets are periodic, yet here is the theory propounded fifty years before Halley published his prediction of the return of Halley's Comet.

The lecture of Mr. Hooke mentioned by Pepys was probably of a scientific nature, and very likely of more consequence than the reference in the Diary would indicate. Perhaps, as Pepys suggests, it was printed.

What I would like to know is, Did Mr. Hooke put forward a real theory of the periodicity of comets, and was his theory founded on a scientific basis? If so, he is entitled to much of the credit that has been given to Halley. Can you enlighten your readers on this subject?

ALBERT J. BROOKS.

BROOKLYN, NEW YORK, U.S.A.

DEVELOPING A PLATE AS A POSITIVE.

To the Editors of "KNOWLEDGE."

SIRS,—The notes on photography in the June number of "KNOWLEDGE" reminded me of an experiment I made in 1897 with the idea of developing up as a positive a plate exposed in the ordinary way. I first developed the plate as a negative in the ordinary way, washed, and without fixing bleached it in a bath of copper sulphate and sodium chloride; I then washed again and placed the plate in a bath of dilute ammonia; I then washed the plate and exposed it to light for a brief moment, and then redeveloped and fixed. The result was, as expected, a positive, but it was fogged and flat.

I wrote to you about this solitary experiment some years ago, having been reminded of it by an article in "KNOWLEDGE." In reply you suggested that I should repeat the experiment, but omit the ammonia bath, the idea being, of course, that silver chloride is much less sensitive to light than silver bromide. I, however, had then no time for any hobby, and I did not repeat the experiment until recently.

I have now repeated it, and I at first omitted the ammonia bath, as recommended by you; but I used ferric chloride as the bleaching agent, as, with the omission of the ammonia bath, there could be no danger of a deposit of ferric hydroxide in the film. I exposed the plate after the image had been converted into silver chloride to the light of a three candle-power electric lamp for forty-five seconds at a distance of three feet (obviously too long an exposure), and then redeveloped with ferrous oxalate, which I had used for the development of the original image. To my utter surprise, I obtained not only a negative, but a negative absolutely free from fog, and with no trace of a reversed image, though distinctly flat. I washed the plate, and then intensified it with mercury, and it now yields perfect prints.

I then repeated my experiment on my own lines, using the ammonia bath and copper sulphate, plus sodium chloride, as the bleaching agent, and mitol-hydrokinone as the developer. After two partly successful attempts, I got a perfect result, and I can now get good results with certainty. The positive, after redevelopment and fixing being a reversed positive, gives good results in printing by the powder process. There is, however, just a trace of general fog, which renders it useless as an ordinary transparency without further treatment. But with slight reduction, followed by intensification, a perfect lantern slide is obtained.

In order to obtain good results it is essential (1) to develop the first image with some clean developer, such as metol-hydrokinone, rodinal, and so on (pyro and iron are not permissible without very special precautions); and (2) to develop until, not only the high lights, but the half-tones show well up on the glass side of the plate.

If the first image is not sufficiently developed, the whole plate will go creamy white when put into the copper sulphate bath, and the result will not be good. If the first image has been sufficiently developed the image will still show up black in the copper sulphate bath *in ruby light*. Three minutes in this bath, a rinse in water, and three minutes in the ammonia bath are ample. If the plate be then viewed by transmitted light, it will already be seen to be a positive. The rest of the operations is then carried out in daylight, *i.e.*, the redevelopment and fixing.

I used as bleaching agent a bath of—

Copper sulphate	24 grains
Sodium chloride	24 grains
Water	1 oz.

and a ten-per-cent. ammonia bath.

The most interesting point, really, is the result I obtained with ferric chloride, omitting the ammonia bath. The exposure to light which I gave was obviously much too long, but the mathematical chance that I accidentally hit off the exact exposure to produce exact solarisation is exceedingly small.

MANDALAY, BURMA. H. E. McCOLL.

XUM

THE SOUND OF THE GUNS.

To the Editors of "KNOWLEDGE."

SIRS,—The remarkable distinctness with which the guns, fired about one hundred and thirty miles away in the North of France, are heard across Kent requires special explanation, since the sound appears to become inaudible, or less distinctly audible, at intervening places; and there are many difficulties in the way of supposing it to be conveyed by direct rectilinear transference. Even if some bending of the waves downwards be admitted, the difficulties are not overcome. The true explanation is, I think, as follows: Using the analogy of light, we know that, with rays passing from a denser to a less dense medium, there is a certain angle, known as the "critical angle," such that when rays passing from the denser to the less dense medium strike the under-surface of the denser medium, so as to form with the perpendicular, let down from the point of incidence into the denser medium, an angle equal to the critical angle, they are totally reflected back into the denser medium. This, it seems to me, is exactly what happens with the sound of the guns. From the mouth of a gun the sound travels along the radii of an ever-expanding spherical wave front, and the "rays" of sound, which reach the surface of the atmosphere from below at the critical angle for rays passing from air into aether, or a so-called vacuum, are totally reflected. That the atmosphere is bounded by a definite surface I have no doubt; but I must not trespass on your space by discussing the question. The truth, or otherwise, of the explanation I have given is capable of being put to the test by noting the distance at which these distant sounds of the guns are most clearly audible by direct propagation, provided we know either the critical angle for sound vibrations passing from air into aether or the total height of the atmosphere. The critical angle is the angle whose sine is the reciprocal $\left(\frac{1}{\mu}\right)$ of the refractive index for sound vibrations passing from air into a so-called vacuum, and, therefore, if we had this refractive index the critical angle is easily obtained, and also the height of the atmosphere. Again, if we had the perpendicular height of the atmosphere and the distance from the source of the sound to the place where it is most audible, the critical angle is readily calculated. I cannot, however, find accepted values for either the refractive index for the sound or for the total height of the atmosphere. With such information as I have before me the probabilities appear in favour of the view that the audibility of the sound of the guns one hundred and thirty miles away is due to "total reflection" from the under-surface of the terrestrial atmosphere.

TONBRIDGE. HUGH WOODS.

REVIEWS.

CHEMISTRY.

A Laboratory Outline of Elementary Chemistry.—By ALEXANDER SMITH. 280 pages. 7½-in. × 5-in.

(Bell & Sons. Price 2/- net.)

This little book has been written as a practical companion to the *Textbook of Elementary Chemistry*, which was recently reviewed in these columns. The experiments have been carefully chosen so as to illustrate most of the ground covered by the other book, while at the same time requiring only simple forms of apparatus and inexpensive chemicals. At the beginning of each exercise the object of experiment is mentioned, and at each stage of the work the student is encouraged to record the facts he observes and to draw deductions from them. The system is admirably adapted for developing a habit of scientific thought, and, if used in conjunction with the textbook, should enable a student working by himself to gain a good practical knowledge of the elements of chemistry.

C. A. MITCHELL.

A Junior Chemistry.—By W. WILLINGS. 280 pages. 7½-in. × 5½-in.

(Blackie & Sons. Price 2/6.)

In estimating the value of a new addition to the already numerous books for beginners it is necessary to see in what respect it offers advantages over its predecessors. In the present instance this little book resembles many others in being intended as a guide for those preparing for the Junior Local Examinations, but at the same time it is much more than a mere "cram book." Its primary aim is to develop scientific methods of thought from the very beginning, and it seems well adapted for this purpose. A novel feature for an elementary book is that in the quantitative work the methods employed by eminent chemists in establishing certain theoretical principles are described, and it is urged that the student should obtain results of sufficient accuracy to confirm such generalisations. Each section concludes with a series of questions, many of which have been set in local examinations, and there are useful tables of equations for reference.

C. A. MITCHELL.

NOTICES.

BIRDS' EGGS LAID IN THE ZOÖLOGICAL GARDENS.—At the meeting of the Zoölogical Society held on October 24th Mr. D. Seth-Smith, F.Z.S., Curator of Birds, exhibited a number of birds' eggs which had been laid in the Society's Gardens during the last few years. The specimens shown included eggs of Tinamous, Cassowaries, Cranes, *Turnix*, *Apteryx*, and the Kagu, as well as species of Pheasants, Waterfowl, and Passerine birds.

IMPROVED IMMERSION OIL.—The cedar-wood oil used for immersion objectives hitherto obtained from the Continent is not now to be had, but the problem has been solved by Messrs. Flatters & Garnett, of Manchester. They have made a number of experiments, and have produced an oil with the refractive index of 1·51, which Mr. E. M. Nelson has pronounced to be the best oil that he has ever used. We think that Messrs. Flatters & Garnett are to be congratulated on their success.

MR. BAKER'S CATALOGUE OF SECOND-HAND INSTRUMENTS.—Now that new apparatus is difficult to obtain, the classified list of second-hand instruments which Mr. Baker publishes quarterly has an additional interest and value. The issue for October, which is before us, contains the same varied series as usual, and we commend it to our readers.

MR. MURRAY'S FORTHCOMING WORKS.—Among the new books announced by Mr. Murray are "Memories of Sir David Gill," by George Forbes; "What is Instinct," by C. Bingham Newland, which deals with telepathy and subconsciousness in animals; and a new edition of Lock's "Recent Progress in the Study of Variation, Heredity, and Evolution," revised by Leonard Doncaster.

XUM